

TITLE: Innovative Fresh Water Production Process for Fossil Fuel Plants

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1. Abstract

Project Rationale and Objective

World fresh water resources have been steadily on the decline since the 1950's. Many measures have been taken to address this problem, including the installation of desalination plants. Since 96% of the world's water supply is saline or brackish, desalination appears to be an attractive technology to meet the increasing fresh water demand. In the United States there exists significant interest in developing clean-coal technologies for electricity generation to meet the growing electricity demand. Power generated from fossil fuels, especially coal, places a large demand on fresh water resources. Approximately 30 gallons of fresh water are required for every kWh of power produced from coal. This places fossil fired power plants in direct competition with processing industries and municipalities for fresh water resources that are on the decline. In some regions of the nation (Southeast and Southwest) fresh water is in such low supply, the environmental and regulatory concerns could be such to inhibit further development of clean-coal power generation technologies. Recently Klausner et al. (2004) described an innovative Diffusion Driven Desalination (DDD) process for the distillation of mineralized water. When the process is driven by waste heat derived from low pressure condensing steam within the main condenser of a steam generating power plant, there exist opportunities to produce large quantities of distilled water at a fraction of the cost of conventional desalination technologies. The objective of this research project is to study the performance of the DDD process over a wide range of possible operating conditions and develop the necessary engineering models to scale it up from a laboratory facility to a full-scale desalination plant producing millions of gallons of fresh water per day.

Accomplishments Achieved During the Current Period of Performance

Water evaporation for the DDD process occurs within the diffusion tower. An experimental facility has been fabricated that includes a diffusion tower where water and air mass fluxes range from about 0.8-2.0 kg/m²-s. Extensive heat and mass transfer measurements have been compiled. A model has been developed for predicting the rate of evaporation and the exiting thermal conditions from the diffusion tower. It has been found that the comparison between the measured and predicted thermal conditions is excellent. Figure 1 shows the predicted exit humidity and exit air and water temperatures from the diffusion tower over a range of air mass flux.

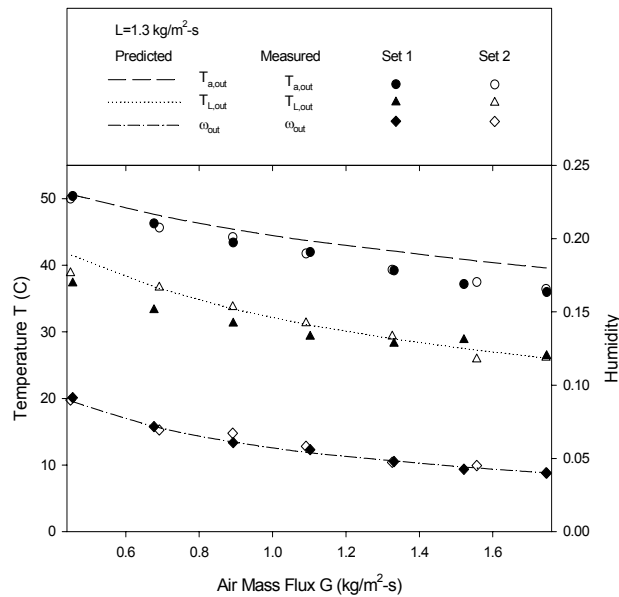


Figure 1 Comparison of predicted exit conditions with the experimental data for liquid mass flux $L=1.3 \text{ kg/m}^2\text{-s}$.

Extensive measurements of pressure drop through the diffusion tower have been made, and a correlation has been developed for predicting the pressure drop. Using the thermal model and pressure drop correlation, the required energy to produce a unit of fresh water has been thoroughly analyzed. It has been found that it requires approximately 0.0015 kWh of pumping power to produce a kg of water. In contrast reverse osmosis technology requires approximately 0.005 kWh of pumping power to produce a kg of water.

Plans for the Remaining Performance Period

- Fabricate direct contact condenser and compile a data base for heat and mass transfer properties within condenser
- Develop analytical models for predicting the heat and mass transfer performance within the direct contact condenser
- Evaluate the fresh water production rate using the laboratory scale DDD facility over a wide range of operating conditions
- Utilize the analytical models to project the performance of the DDD process for a full scale desalination plant integrated with a typical coal-fired power plant

2. List of Published Articles Associated with Project

Klausner, J.F., Darwish, M.Y., and Mei, R., 2003, "Computational Method and Design of a Packed Bed Diffusion Tower for the Desalination of Seawater," *Proceedings of the 2003 ASME Summer Heat Transfer Conference*, paper HT2003-40438, Las Vegas, July 21-23.

Li, Y., Klausner, J.F., Mei, R., 2004, "Heat and Mass Transfer for the Diffusion Driven Desalination Process," to appear in *Proceedings of the ASME-ZSIS International Thermal Science Seminar*, Bled, Slovenia.

Klausner, J.F., Darwish, M., Li, Y., and Mei, R., 2004, "Innovative Diffusion Driven Desalination Process," *J. Energy Resources Technology*, in press.

3. List of Students Supported with Project Funds

Yi Li, graduate student

Jessica Knight, undergraduate student

Diego Acevedo, undergraduate student